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EXPANDED TECHNICAL ASSISTANCE PROGRAM

FAO Report No. 938

Report to the Government

of

INDIA

on

EQUIPMENT FOR PLANT PROTECTION

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

ROME, 1958

COMMONWEALTH MYCOLOGICAL INSTITUTE
14 AUG 1961

Report No. 938 Project IND/AgL

REPORT

to

THE GOVERNMENT OF INDIA

on

EQUIPMENT FOR PLANT PROTECTION

based on assignment of

R. J. Courshee
FAO Agricultural Engineer

Rome, 1958

FAO/58/8/6214

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INTRODUCTION

The Government of India, in the Technical Assistance Program submitted to FAO for the year 1956, requested the provision of an Agricultural Engineer (Spraying and Dusting Techniques). The terms of reference for this expert were as follows:-

> "to advise and assist the Government in the testing of plant protection equipment for various uses under varying conditions in the country, and to assess the suitability of the different types of sprayers, dusters and other equipment which are necessary for plant protection purposes."

To fulfil this request, FAO provided the services of Mr. R.J. Courshee. He arrived in India in November 1956 and remained there until October 1957. During the period of his assignment he worked closely with the Directorate of Plant Protection, Quarantine and Storage, New Delhi.

Acknowledgments

The work was guided and assisted by officers of the Plant Protection Directorate, the State Plant Protection Organizations, and many workers in the Agricultural Research Stations throughout India. Grateful acknowledgment is made for the close cooperation and personal assistance provided by all officers of these departments. Special credit in this respect should go to the following:-

Mr. K.B. Lal	Plant Protection Adviser to the Government of India
Mr. B.K. Verma	Directorate of Plant Protection, New Delhi
Mr. Swijit Singh	Directorate of Plant Protection, New Delhi
Mr. T.S. Ramakrishnan	Rubber Research Station, Rubber Board Kottayam, Kerala
Sardar Singh	Government Agricultural College, Ludhiana, Punjab.

SUMMARY OF RECOMMENDATIONS

The economic and efficient execution of the plant protection program envisaged by the Government of India depends to a very great extent on the proper selection and operation of the equipment required for the actual field application work. To promote the proper direction and conduct of this work, the following recommendations are made:-

1. Proper application methods and machines are so important to the success of the overall plant protection program in India that they warrant the establishment of a separate equipment section in the Central Directorate, with a qualified officer in charge to guide and control all aspects of this work. This Equipment Section should be responsible for:-

   (a) making critical comparisons between methods of applying pesticides to crops;

   (b) testing locally manufactured and imported machines and advising on their suitability for various pesticides, crops and conditions of application;

   (c) developing suitable equipment where none presently exists; in this regard, particular attention needs to be given to the development of inexpensive, simple machines within the financial and technical capacity of the small farmer to own and operate;

   (d) advising local manufacturers on machine design requirements;

   (e) training specialist plant protection extension staff in application methods and machines;

   (f) assisting State plant protection organizations in conducting an extension program on plant protection machinery, its selection, use and maintenance.

2. The general policy should be to encourage and train farmers to own and operate their own pest control equipment. Government assistance in the form of a hire service or loan of equipment should only be considered as a temporary measure to introduce correct types of machines, to train operators and to assist in the control of pests which cannot be countered successfully by individual farmers.

SUMMARY OF ACHIEVEMENTS

The overall effects of a relatively short term advisory assignment are seldom immediately apparent when the assignment pertains to such a broad field as plant protection. It is hoped however that some of the projects which were started and the advice given to officers in charge of this work will in the future serve to improve pest control practices in the country. The following is a brief summary of the points of study on which most emphasis was placed.

Survey of Problems relative to Selection and Use of Equipment

In order to properly advise on the types of plant protection equipment which are most satisfactory for Indian conditions and on matters relative to the efficient use of this equipment, it was necessary to obtain a clear understanding of the crops which were most seriously affected, the types of pests which caused the greatest damage, the field conditions under which crops most seriously affected were grown, the pesticides employed and the supply and maintenance facilities for both chemicals and equipment. In order to obtain a good basic appreciation of these conditions most State Plant Protection Centres and the Substations under control of the Plant Protection Directorate were visited. During these tours every opportunity was taken to inspect the actual conditions which existed.

Research on Methods of Application

From this survey it was apparent that under existing field and labour conditions, for most crops, hand operated equipment would for many years be the most applicable. Hand bellows dusters and hand operated knapsack sprayers fitted with nozzles to apply between 15 and 20 gallons of spray an acre would be the most suitable types of equipment.

Power operated equipment should, if used for ground crops, be modified to enable the spraying to be done in regular swathes, by fitting booms which can be carried by hand and long, lightweight hoses.

To demonstrate the point that small volume spraying is effective on cotton the same amount of active chemical per acre was applied to three different plots, only in one case it was contained in 2 gals. of water, in the second in 8 gals. and in the third in 80 gals. Each method of application gave equally effective control, but the low volume application was done much more quickly and easily and resulted in much lower labour cost. The importance of preventing evaporation under low volume drift spraying by adding a small amount of molasses to the spray mixture was also demonstrated.

An experiment was also carried out on treating rubber trees against early leaf fall fungus. The normal method of application is by high volume run-off spraying using 400 gals. of spray mixture to the acre. This method requires approximately 120 man-hours of labour per acre. The new method tested was to apply the fungicide in the form of a fine oil mist by means of a low powered mist blower machine. Using this method only 2 gals. of spray were applied per acre and the labour requirement was cut from 120 man-hours to 2 man-hours per acre application. It is clear that the saving in time, which can also be achieved by dusting, is only a first step. The next stage of the work for the equipment section should be to determine what form of spray deposit is effective, durable and safe.

It is certain that considerable savings in time and cost can be made on other crops also by changing the application method from run off spraying to an effective form of small volume spraying. To do this it is essential to spray in regular swathes and teach the operators the value of uniform application of the pesticide and, of course, to carry out experiments to compare small volume and run off spraying when both applications contain the same amount of pesticide.

Machinery Development

Most types of equipment suitable for plant protection work in India can be manufactured in the country, however, the Government should give guidance and assume leadership in developing and testing suitable machines for manufacture. A small workshop at the Central Directorate of Plant Protection was therefore built up and equipped, and an attempt was made to start this development work. The main effort in this field was concentrated on the design of a simple hand duster which was within the purchasing power and technical competence of the small farmer to own and operate. It is felt that the type developed is considerably better for local conditions than those previously available in that it is robust and cheap (it costs 2 rupees) and the adequate agitation ensures a regular feed of dust. In this way not only does the farmer have his own machine but he has one which is good in applying pesticides. He should not be misled into assuming that a more complex machine is better and trials of effectiveness and working rate comparing the cheap and the costly machine should be made. As a guide for future test work an outline of test procedures for sprayers and dusters was also drawn up.

Advice to Manufacturers

Most of the major manufacturers of plant protection equipment in India were visited. Their manufacturing methods were inspected and advice given on the types of equipment and designs most suitable for various conditions.

In cooperation with the Indian Standards Institute, an attempt was also made to encourage manufacturers to standardize on the basic parts (example: nozzles) used in all types of spraying equipment.

Training

An officer of the Central Plant Protection Directorate was given advice and training in design and test procedures on equipment. In addition, as many as possible of the plant protection officers, both at the Central Directorate's Substations and at the State Control Centres, were given advice on the selection, operation and maintenance of machines.

In order that this work might continue, training pamphlets were prepared and issued on the following subjects:-

Application principles
Reaching tall trees with spray
Preferred types of machinery
Small volume spraying
Machine testing
A handbook for spraying machinery operation.

Lectures on the selection, operation, maintenance and testing of spraying and dusting equipment were also given to plant protection advisory staff and other interested personnel at Ludhiana, Simla, Indore, Coimbatore and Delhi, and at the All-India Horticultural Conference.

Demonstrations

During visits to the various Substations of the Central Directorate and to the State Control Organizations, whenever time permitted field demonstrations were conducted to train local staff and to demonstrate machines and application methods to farmers.

FACTORS AFFECTING THE SELECTION AND USE OF PEST CONTROL EQUIPMENT IN INDIA

Area and Crops Affected

Of the approximately 300 million acres of crops grown annually in India, it has been estimated that at least 100 million acres suffer insect and plant disease infestations which are serious enough to warrant preventive treatments. Annual losses from plant pests and diseases can and have reached serious levels, both from the financial standpoint and in the form of badly

needed food products. If yields on the 100 million acres which it has been estimated require preventive treatment were depressed even as little as 10 per cent, it would represent a financial loss of approximately Rs.6 per acre, or a total loss to the country of at least Rs.300,000,000.

It should be realized that it is difficult to counter economically losses worth only Rs.3 an acre and cheap methods are essential. Even then, for some time yet any money used might be better spent on improved crop varieties and raising their nutritional status. This area is what may require treatment annually at some time in the future.

The point at which it is worthwhile to use chemical pest control on crops of low value, requires careful study of the whole cost and of the probability and magnitude of the advantage to be obtained. The application method has a large influence on the outcome of the operation and this point is not being studied adequately on most crops.

Those crops on which chemical pest control measures are economically justifiable are cotton, sugar cane, rice, tree fruits, rubber, coconuts, garden vegetables, but only if these crops are irrigated in the dry areas and supplied with fertilizer.

In all, the areas likely to warrant treatment now are in excess of 10 million acres and should be expected to grow rapidly towards the probable final figure of 100 million acre applications annually.

Present Extent of Control

No reliable figures are available on the average annual total crop area treated for pest control in the country as a whole. Some indication of the extent of treatment can however be estimated from the sales of pest control chemicals. During the first five-year plan, approximately Rs.15,000,000 was spent on this type of chemical. Since effective control using the types of chemicals sold requires an average per acre application of chemicals to the value of Rs.4, we can calculate that the area treated in five years was approximately 15 million divided by four, or 3,750,000 acres. This means that the average acreage treated annually was only in the order of 750,000 acres, or 0.75 per cent of the 100 million acres which it has been estimated require treatment annually.

The area now treated is uncertain especially because it increases each year and a large fraction is done by farmers themselves and does not appear in official statistics. But it is probably only 10 per cent of the work which is worth doing now and 1 per cent of the eventual target. These figures indicate only orders of magnitude.

A very large percentage of this treatment has been carried out by State Plant Protection Services, either directly as a hire service or by loaning machines to farmers so they can do the work themselves. Relatively few farmers own and operate their own equipment. The Government, through the Substations of the Central Directorate of Plant Protection and the State Plant Protection Services, own approximately 50,000 spraying and dusting machines. The majority of these are hand operated dusters and large volume type run-off sprayers. A considerable number of power units of varying sizes for both spraying and dusting are also available.

In the past, each State has individually specified and purchased the types and makes of machines which they use. In most cases this selection has been done with little knowledge of the adaptability of the machine to the specific conditions, or of its quality of construction. Very little guidance has been provided by the Central Directorate on this important matter. Most States therefore have a very heterogeneous mixture of types and makes of machines, many of which cannot be economically used under local conditions and due to the wide variety of types and makes, maintenance and supply of spare parts are a great problem.

The equipment has often been used, or rather misused, by people with no training in its proper operation, care and maintenance. This has resulted in excessive breakage and wear of machines and large numbers have been rendered unserviceable and beyond economic repair long before they should have.

Cropping Conditions

By far the greatest cultivated area of land is in small holdings and is used for the production of food crops for the farmers' own consumption, with small quantities for local sale. Statistics show that the 300 million acres of agricultural land in India is divided into approximately 40 million individual holdings. This means that the average holding is somewhat under 8 acres. This figure does not give a true picture however, since, when one takes out the areas farmed as large estates, the individual acreages farmed by the peasant farmers are very small. A large proportion of the land is in the form of individual holdings smaller than 3 acres, but no accurate figures are available on this. In many cases these small holdings through inheritance laws have become fragmented and scattered so that actual crop production is carried out on very small plots of half an acre or less in size.

Poor roads between villages hinder the movement of large and heavy equipment. For this reason and because plots are small, hand operated equipment is more practicable and it will be found, usually, to be adequately effective.

The second class of farms consists of holdings of from 25 to 100 acres which are farmed more scientifically and similar in many respects to western standards. On these farms the majority of the crops are grown for sale and

therefore the farmer has more capital available. Timeliness of application of pesticides is of course most important and, in that on this class of farm greater acreages must be covered in a limited period, heavier power equipment becomes more applicable. Better communications usually exist in these areas and the fields are accessible by wheeled equipment. Farm operators are also better acquainted with mechanical things and thus are in a better position to properly use and maintain larger types of machines.

The third type of farms might be called the plantation farms. These may range in area from 50 acres to very large holdings. The crops grown are often of a more specialized type such as tree fruits, coconuts and rubber, which require specialized equipment for effective treatment. This is the main type of farm where powered equipment is most applicable and in many cases is essential.

Value of Crop

Crops are often of very low value and any excess is difficult to sell. Therefore, even when the advantage accruing from crop protection exceeds its cost, and this is often doubtful on poorly nurtured crops, the actual cash value to the farmer may not be high enough to permit him to spray. Also, he has to find the money for the work even if a profit is assured at harvest time.

For these reasons, only equipment which is very cheap to purchase, simple to operate and requiring little maintenance will be acceptable to him. If possible, the construction should be such that repairs can be done by the farmer himself or by a local repair shop.

On the other hand, where crops are grown for sale and represent a cash value per acre, losses through pests and diseases are clearly visible and the farmer can easily calculate whether, on the average, costs of application of pesticides will give him a net gain. This type of farmer usually is most interested in all phases of plant protection.

Local Knowledge concerning Plant Protection

There seems little doubt that the greatest overall loss from insects and plant diseases is made up among the thousands of small farmers. In addition to the lack of capital available to these people however a very serious obstacle to the more widespread use of control measures is the lack of information on plant pests and diseases, and on materials, methods and timing of applications to effect control. Unfortunately a large percentage of these people are also illiterate, therefore, printed pamphlets and press articles are of little use to them. It must be realized however that information on the subject must be provided to them. Visible instruction methods such as field demonstrations and pamphlets consisting mainly of pictures would seem to be the most satisfactory method of providing this training.

Economic pesticides are available for most pests. The problem remaining is to persuade the farmers that they will profit from applying those pesticides; that is by owning a machine and using it. But the obstacles often are that the application is not yet always able to provide a profitable, certain control of the pests when the farmer does the work, and also efforts to teach the farmer the value of the work and how to do it are not yet fully successful. So although the main task is to get present knowledge applied, this must be simultaneous with improvements on methods used elsewhere so that they become more reliable for and applicable to the conditions in the countries where plant protection is being introduced.

Cost of Control

The main factor affecting the cost of control is the chemical used. The cost of the application of this chemical should be far smaller, and usually is. Every effort should be made therefore to develop application methods which will make the most effective use of chemicals, to introduce equipment which will apply the chemicals in the desired way and at the same time will be cheap to purchase and easy and economical to operate and maintain.

CONSIDERATIONS REGARDING FUTURE WORK IN THE FIELD OF PEST CONTROL EQUIPMENT

It is a well established fact that pest control measures should be applied to a much greater extent in India than they have been in the past. In order for this work to be widely practised, however, control measures must be effective, cheap and easily carried out, otherwise it will be extremely difficult to convince the farmer to do this work.

The cost of protection depends on the selection of pesticide, its dosage rate and on application costs.

The speed and ease with which a crop can be covered again is greatly affected by the type of equipment used.

It is thus very obvious that with the present knowledge of insect pests and control chemicals, the effectiveness of control and the extent to which crop protection is practised depend very largely on the selection, operation and maintenance of equipment to apply the protective chemicals to the crop.

The Directorate of Plant Protection, Quarantine and Storage has in operation a quite effective establishment to study and guide most phases of plant protection work. There is a well established Entomology Section to deal with types of insects which cause damage, a Pathology Section to study plant diseases and a Pesticides Section to study control chemicals. Up to

the present however no section has been established, or an officer appointed, to deal specifically with methods of application and equipment. It is strongly recommended that such a section be established. It might be called the Equipment Section and the officer in charge the Plant Protection Equipment Officer.

This Equipment Section, as is the case with other sections in the Directorate, should be responsible for basically five main types of work as follows:-

Administration
Research and Development
Training
Extension
Supply of Equipment.

The following are some items which might be taken into consideration in the conduct of these activities.

Research and Development

Although research work should be coordinated by the staff of the Central Directorate and much of it could be done at headquarters, a very large percentage of the studies would have to be undertaken at the various sub-stations and by State plant protection organizations where conditions pertaining to the infestation and the crops affected exist.

The particular field of research and development which might be best undertaken by the Equipment Section should emphasize studies of methods of application and the utilization of equipment already being used for the same, or a similar type of work in other parts of the world. It is not felt that there is a great need for the development of completely new types of machines. If a careful survey and study is made, it is usually found that a suitable piece of equipment is already in existence. In some cases such equipment may need to be modified somewhat to suit specific local conditions. The Equipment Section could well undertake this work.

The selection of equipment for a specific plant protection job resolves to a choice, first, of basic type - duster, low volume sprayer or high volume sprayer - and secondly, the size within this type. The nature of the infestation to be controlled and the type of crop to be treated are the main factors which determine the basic type of machine. The general agricultural conditions such as labour supply, size of holdings, technical skill of operators and available repair facilities are the main factors to be considered when determining suitable sizes, and particularly whether they should be hand operated or power driven.

Concerning size, it is suggested that major consideration be given to the study of portable hand operated and small power machines. These in most cases are the only types which are within the purchasing power of the majority of farmers and also, due to inaccessibility of fields and to cropping conditions, only portable, small size machines can be effectively utilized.

Regarding basic type - the choice between duster and high or low volume sprayers - dusting is the simplest method of application, is best suited to portable machinery and usually requires simple and relatively inexpensive equipment. Dusting however is usually somewhat less efficient than spraying, probably because of the low retention of the dust and somewhat increased cost of chemicals required.

Large volume spraying is usually effective and reliable, but the costs of supplying, carrying and pumping by hand the large quantities of water required, and the amount of labour entailed make this method rather unpopular.

Small volume spraying to some extent overcomes the failings of each of these previous methods while retaining the good points of both. The equipment for this type of application in most cases can be hand operated and the volume of liquid required is small enough to allow it to be transported by hand while being applied to the crop.

The question of complete spray cover, that is, both on the top and underside of plant leaves, is still a controversial point. This fact contributes considerably to the convenience and effectiveness of low volume spraying equipment. Crops should, as far as possible, be treated in regular swathes. By the use of a boom uniform application can be obtained if both the output of the machine and the forward speed of travel remain constant.

One of the main functions of the Equipment Section in the research and development field should be to advise manufacturers on design requirements and to work closely with them in developing proper types of equipment and manufacturing methods which would produce good quality machines at the lowest possible price.

Training

The Central Directorate of Plant Protection should be recognized as the "clearing house" for information on all matters relative to plant protection work. State organizations should assume the responsibility of spreading this knowledge to the farmers. However, in order that the right information is disseminated, the Central Directorate should provide training and information to field staff in the form of printed literature and an established program of field training centres.

This again must be a cooperative effort within the Directorate, each section contributing information and training on the specific phase of the work for which it is responsible.

In many countries such a Central Directorate publishes a regular monthly bulletin covering all the latest developments in the field and advising on control work that should be carried out in the months immediately following. In each case where an insect infestation or disease is discussed, the Entomology and/or Pathology Sections would cover basic information on the nature, feeding habits, etc., of the disease or insect. The Pesticides Section would contribute information on the control chemicals to be used and the Equipment Section would outline recommended methods of application and suitable machines.

In addition to the issuing of printed information, the staff of the Central Directorate should carry out regional training centres for State personnel on all phases of plant protection work.

The central staff should also be available to give talks at producer association meetings on plant protection problems relative to the particular crop or crops handled by any such association. They should also assist agricultural schools and colleges in setting up course work on this subject and on occasion may even be called on to give some lectures.

Extension

The provision of information direct to the farmer on all problems relative to plant protection should be the responsibility of the individual State plant protection organizations. The Central Directorate should however provide plant protection extension specialists to assist in training State personnel in extension methods and procedures relative to this work and in supplying them with information for distribution.

Under local conditions extension work in all fields must be largely limited to visual means. Printed information covering the recognition and control of all major infestations should be made available for widespread distribution. The preparation and printing of this information should be the responsibility of the Central Directorate. Such printed material must however mainly be in the form of illustrations with very little text. It must also be attractive so the farmer will read it, and should be printed on durable paper so it is not easily destroyed.

Demonstration plots and field demonstration days, it would appear, are the best method of arousing the farmer's interest and of spreading information on plant protection matters. Again, the State organizations should be responsible for conducting these demonstrations. However, to assist and train them in this work, equipment specialists from the Central Directorate should be available. They would also supply State organizations with printed material outlining suggested programs and procedures for field demonstrations.

All this work should of course be closely correlated and carried out in conjunction with the overall agricultural extension program.

Supply of Equipment

It should be realized that in very few countries do governments make plant protection equipment available to farmers either on loan or as a hire service. Once the financial benefits of protective measures are well recognized by the farmer, and when suitable equipment is available which is within his purchasing power and technical capacity to own and operate, he will usually readily acquire and use it without government assistance. If an adequate research, training and extension program on all phases of plant protection is carried out by the government, the farmer will know the value of protective measures and also suitable equipment will have been developed and made available. These phases of the program as outlined previously are therefore most important.

An Equipment Hire or Loan Service may however at the start of the program assist considerably in demonstrating proper application methods and machines and in training farmers in the use and maintenance of equipment. It is most important, when such a hire or loan service is initiated, that great care be taken in the selection of equipment and that the makes and types used be limited to as few as possible. Otherwise, rather than giving the farmer information on correct types, it will only tend to confuse him.

The establishment of private contract spraying and dusting services should be encouraged. In many cases such contractors can perform plant protection work more effectively and cheaper than the farmer could by owning his own machines. This applies particularly to crops on which specialized equipment, probably of the power type, is most suitable.

Where a government has in operation a hire service therefore, it is important that the charges made are such as to allow a private contractor to operate profitably. If, in order to popularize a program, charges lower than actual costs are levied, it should be clearly pointed out that this is the case, and that the government is bearing some of the cost simply to introduce recommended practices, or to meet emergency conditions.